geology should be fit to advise in regard to a mining venture. The teacher may be an expert in the economics of the profession, but the proof of the fact is not to be found in his scientific work or in his success as an instructor. If he has not had the other training it may be safely assumed that he will be totally unfitted to wrestle with the tricky fellows who try in amazingly varied ways to deceive him, or even with the tendencies of his own mind, which naturally lead him to see riches where others fancy they discern them.

In the interests of our science it is most desirable that all expert work should pass into the hands of a body of men who should bring to their task so much of geology as is needed for the particular inquiry, commonly not very much, and who can join with it the more important practical acquaintance with the miner's art and the conditions of trade which relate thereto. In certain cases the men of theory may well serve these experts; all their inquiries are likely to be of service in the determinations, but on them should not be the responsibility for the business side of the problems. There is little the geologist does in the way of research which may not have some practical application to the affairs of men, but he should not mistake this possibility of usefulness as an indication that it is for him to give his inquiries an economic turn.

CONCLUSION.

We thus see that geological science, like the most of the other branches of natural learning, has two distinct points of contact with society—that of instruction and that of economic affairs. In each of these fields of usefulness its services to man have been great and are to be far greater in the time to come. As for instruction, the task is to give to men an adequate perspective for their lives. It is to ennoble our existence by showing how it rests upon the order of the ages. In the economic field it is to show the resources which these ages have accumulated in the earth for the service of the enlarged man, who is to attain his possibilities by a full understanding of his place in nature. To do the fit work we need to combine the functions of explorers and guides zealous to open the way to the unknown, and those of teachers who take care that the youth of our time are led into the land which we know to have so much promise for man.

SOME VALUES OF STELLAR PARALLAX BY THE METHOD OF MERIDIAN TRANSITS.

IN this article are presented values of the parallax for thirteen of the list of nearly ninety stars upon which I have been engaged at this observatory the past two years. The results here given include the values presented at the Springfield meeting of the American Association for the Advancement of Science, with some additions. They are the results of preliminary solutions based upon all my observations of these stars available at the time, and equal weight has been given to each observation.

The method employed is that of the differences of meridian transits, and it is believed this is its first application since it was introduced in its present detail by Prof. Dr. J. C. Kapteyn at the Leiden Observatory in 1885–87. He determined the parallaxes of fifteen stars by this method with a high degree of accuracy. The observing consists in noting the successive times of transit of three stars, of which the first and third are comparison stars and the middle star is the one whose parallax is sought. The former should be so chosen as to make the group of three stars as symmetrical as possible in both position and magnitude. Of course, a fine meridian instrument is required, and for the present series the REPSOLD meridian circle of 12.2 c.m. was employed with a power of 180 diameters. To

give the instrument greater freedom the clamp arm was detached from the pier, excepting for a few of the earlier observations. Screens of fine brass wire were used to reduce the apparent magnitude of the brighter stars so as to make them more comparable with the fainter stars. The screens were mounted on a frame travelling north and south and entirely separate from the instrument. They were used not for fear of the errors arising from momentary uncertainty on the part of the observer, but for fear of a systematic change in his habit of noting the bisections of the brighter stars. Such a change might come about gradually during the six months' interval between two successive epochs of observation and would enter directly into the concluded parallax. To prepare each observation of a group of three stars for combination with other observations of the same stars a simple reduction is made. The differences of the observed times are corrected for deviation of the instrument from the meridian and for proper motion of the stars so far as they are known, and then reduced to a common equinox. The effect of the clock rate in well selected groups of stars is rarely appreciable. The solution is then made so as to determine three unknown quantities, namely, the normal difference in time between the middle star and the point exactly midway between the first and third stars, the residual correction for proper motion and the parallax.

The method has certain distinctive advantages and disadvantages to be foreseen which may here be noted. The former are as follows: 1. The absence of any known systematic effect of refraction, thus avoiding any refraction term whatever in the reductions. 2. The simplicity of the observations and reductions and the rapidity with which the former may be secured. 3. The great freedom allowed in the choice of comparison stars as regards distance from the principal star in zenith distance. 4. The stability of the instrument and the fact that it is untouched at the moments of actual observation. 5. The ease with which the condition may be secured that all observations on a given star shall be made with the same position of the instrument and of the observer. As compared with one or another of the modern, refined methods of measuring stellar parallax, the following advantages may also be given: 6. A large dimension of the parallactic orbit is always measured. 7. All observations are made at the same place in the field of the eyepiece. 8. The attention of the observer is directed to one point only at a time.

The disadvantages are as follows: 1. Limitation to meridian passages, so that observations at the time of maximum effect of parallax are in general impracticable through one-half of the year. 2. Limitation in the choice of comparison stars, since brighter stars must be selected on account of the smaller apertures of meridian instruments. This necessitates moreover greater intervals between the stars allowing more time for disturbances to occur affecting the transits of the stars. 3. The necessity of moving the entire telescope in passing from one star to the next, sometimes requiring a change of several degrees in the pointing of the instrument and incurring the risk of inducing strains among its parts. 4. The fact that the instants of observation of any two stars cannot be made simultaneous.

The present observations were made on an illuminated field. In making up the star groups I gave the preference to symmetry of position over that of magnitude. The observing list has seemed too crowded in some places, but the influence of this and of any other adverse circumstances will be better determined by the final discussion. In order to secure, if possible, a fair number of observations at each epoch, I have continued the observing in general on poor

as well as on good nights. Numerous observations have been made on miscellaneous stars, with and without the screens, to determine at any time the personal equation depending upon the apparent brightness of a star; but these have not yet been reduced.

The values of the parallaxes resulting from the present solutions are given in Table I. The average number of observations entering into each value is 35. All the stars have been solved in the regular manner except the last two, which presented a peculiar case to be explained in the following. Of these *85 Pegasi* was reduced with its second comparison star only with an inappreciable parallax as the result.

In Table II. are presented all the previous determinations of parallax that I have found for the stars of Table I., excluding some older and much more uncertain values. The several columns are sufficiently explained by the headings except the third, and here the letters given denote different methods of observing, as follows:

H. By the heliometer.

M_1. By the filar micrometer attached to the equatorial telescope and from measures of distance and position angle combined; M_2, from distance alone; M_3, from position angle alone; M_4, from differences of declination.

Z. By measures of the zenith distances of the parallax star alone, in the meridian.

R. By observations of right ascension in the ordinary manner.

P. By measurement of photographs.

T. By differences of meridian transits employing special comparison stars.

In the case of *α Lyræ* the letter *c*, in the fifth column, indicates that the measures were made from the companion star. The value given for this star from *Peters* is the only *absolute* parallax in the table. For *μ Cassiopeiæ* and *α Lyræ* I have included my own results, assigned the several independent values different weights, somewhat arbitrarily, and combined them all into one mean value given in the table.

TABLE I.

NAME OF STAR.	Mag.	R. A.	Dec.	Prop. Mot.	Parallax.
		h	°		
μ Cassiopeiæ	5.2	1.0	+54	3.″8	+0.″12
Lalande 15290	8.2	7.8	30	2.0	+ .10
Lalande 15565.	7.5	7.9	29	1.2	+ .03
Lalande 18115, *pr*........	8.0	9.1	53	1.7	+ .15
δ Ursæ Majoris...........	3.2	9.4	+52	1 1	+ .13
20 Crateris................	6.2	11.5	—32	1 1	+ .15
γ Serpentis...............	4.0	15.8	+16	1.3	+ .13
η Herculis......	3.7	16.6	39	0.1	+ 20
Lalande 30694............	7.0	16.8	0	1.6	+ .02
70 Ophiuchi..............	4.2	18.0	2	1.1	+ .17
α Lyræ (Vega)............	0.2	18.6	38	0.4	+ .05
Lalande 47019............	8.1	23.9	26	..	+ .24
85 Pegasi.................	5.8	23.9	+26	1.3	+0.02

TABLE II.

NAME OF STAR.	Authority.	Method.	Parallax.	No. of Comp. Stars.	Probable Error	Weight.
μ Cassiopeiæ...	O. Struve...	M_1	+0.″342	1	±0.052	6
	Schweizer ..	M_3	+ .084	1	.060	5
	Pritchard...	*P*	+ .035	2	.018	10
	Flint........	*T*	+ .120	2	.044	8
	Weighted Mean.		+0.130		±0.020	
δ Ursæ Majoris	Kapteyn....	*T*	+0.052	2	±0.026	
η Herculis......	Belopolski.. (Wagner)	*R*	+0.40	..	0.072	
70 Ophiuchi....	Krueger....	*H*	+0.150	2	0.006	
α Lyræ.........	W. Struve...	M_2	+0.262	*c*	±0.025	4
	C.A.F.Peters	*Z*	+0.116	..	.050	4
	O. Struve ...	M_1	+0.147	*c*	.010	8
	Johnson....	*H*	+0.141	2	.047	2
	Brünnow....	M_1	+0.212	*c*	.011	6
	Brünnow....	M_4	+0.188	1	.033	2
	Hall	M_4	+0.134	*c*	.006	10
	Elkin.......	*H*	+0.092	6	.019	10
	Flint........	*T*	+0.049	2	.037	6
	Weighted Mean.		+0.138		±0.008	
85 Pegasi.......	Brünnow....	M_1	+0.054	1	±0.019	

As regards the apparent uncertainty of results, the present method cannot take rank with the best work done with the heliometer and the filar micrometer, or perhaps with that done by the aid of photography. As shown by Dr. KAPTEYN's refined determinations, however, this method seems singularly free from systematic error, and its trustworthiness may be higher than that assigned by its accidental error alone. In the present series a material reduction of the apparent uncertainty of any single night's observation of a given star would result from diminishing the weights of the

poorer nights. The average probable error of the parallaxes of Table I. is $\pm 0.''046$, and, therefore, the true values should be within one-tenth of a second of the numbers there given. When we consider average values of parallax, however, we have a more trustworthy determination of the distance of certain stars as a class. Thus ten stars of the list have a proper motion of one second or more. The mean value of their parallaxes is $+0.''11$, with a probable error of $\pm 0.''015$, so that the average distance of these stars is indicated to be such as to require about thirty years to be traversed by light. Table I. contains one star, *Lalande 47019*, which found entrance quite unexpectedly. It was the first comparison star for *85 Pegasi*, and the latter was first reduced in the regular manner but showed a negative parallax. This was explained upon making comparisons of the first star, *Lalande 47019*, with *85 Pegasi* and the third star of the group separately, for the two solutions resulted in positive and nearly equal values of the parallax for the first. The mean of these two values, $+0.''21$ and $+0.''27$, is given in the table. An inspection of the data indicates that this is a real parallax, and not merely an apparent one such as might be ascribed to personal change. The magnitudes of the stars were 8.1, 6.1, 6.2 respectively, and no screens were employed in this group. I included in the examination a number of observations made with the screens expressly as a control on the personal equation depending upon the brightness of the stars. The case of *Lalande 47019* is an interesting one, since the star is faint and the comparison of four catalogue positions extending from 1800 to 1890 gives no plain indication of proper motion. Yet the results indicate that it is the nearest star of the thirteen in the table. With this separate presentation of *Lalande 47019* and *85 Pegasi*, it will be noticed that while some of the parallaxes are very small yet they are all positive. According to the law of chances some of these values should be the lowest possible ones derivable for the individual stars and some should be the highest possible values. The fact that they are all positive and comprised within so limited a range indicates that the observations are not liable to such systematic errors as have even led sometimes to large negative values of parallax, and strengthens the hypothesis that the stars of large proper motion are on the whole comparatively near us.

In the case of two of the stars we have several independent determinations as shown in Table II. For *η Cassiopeiæ*, one of the stars having a remarkably large proper motion, the results indicate a definite parallax of about $0.''13$. The number of separate determinations, however, is few, and we can only say that the chances are that the distance of this star is such that it requires somewhere from 22 to 30 years for its light to reach us. *α Lyræ* has been a favorite object for parallax observations, owing to its brilliancy and its favorable position for northern observatories, and consequently we have a good determination of its distance. The concluded value of the parallax, $+0.''138$, corresponds to a light journey of 23.6 years, and the uncertainty of this result is so small that the chances are that the time actually required is somewhere between 22.3 and 25.1 years, while we may feel confident it cannot be more than 33 years nor less than 18 years, that its light requires to reach our system.

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OZARKIAN EPOCH—A SUGGESTION.

AMONG the voluminous writings on various geological subjects published during the past ten years, there has been frequent mention made of an erosion interval occurring between the Lafayette formation and the lowermost glacial deposits. Those who